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INFLUENCE OF DRIP IRRIGATION RATES AND SOIL IMPROVERS ON THE PERFORMANCE OF SOME SUGAR BEET VARIETIES IN NORTH SINAI

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ABSTRACT: The presented work aims to study the effect of drip irrigation rates and soil conditioners/ improvers on yield and quality of three sugar beet varieties during two winter successive seasons 2012/2013 and 2013/2014 under new land conditions of North Sinai Governorate, Egypt. Statistically split-split plot design was used. Irrigation rates had a significant effect on root length, root diameter, sucrose percentage, root and sugar yields in both growing seasons while it had a significant effect on purity percentage in 1st season only. Irrigation rate of 3000 m^3/fad., over passed that of 2500 m^3/fad., which recorded the highest values of root diameter, sucrose percentage, purity percentage, root and sugar yields. On the other hand, Irrigation rate of 2500 m^3/fad., over passed that of 3000 m^3/fad., which recorded the longest root. Moreover, sugar beet varieties had a significant effect on root length, root diameter, sucrose percentage, root and sugar yields in both growing seasons while it had a significant effect on purity percentage in 1st season only. Marathon variety gave the highest values of root length, root diameter, root and sugar yields. Farida variety gave the highest values of sucrose and purity percentages. Soil improvers had a statistical effect on root diameter, purity percentage, root and sugar yields in both growing seasons while it had a significant effect in 1st season only on root length and sucrose percentage. Iquet compound was the best soil improver that attained the highest values of the studied traits in both seasons. The 2nd order interaction of irrigation rate × variety × soil improver statistically affected on root diameter in 1st season, sucrose and purity percentages in 2nd season and root length, root and sugar yields in both seasons. Using 3000 m^3/fad., of irrigation rate in combination with Humic acid as soil conditioner for Marathon variety was the best combination that recorded the highest root and sugar yield values (30.58 and 5.99 ton/fad., respectively, as a mean of both seasons). However, using the same irrigation rate in combination with the same soil conditioner for Farida sugar beet variety attained the highest purity percentage value (96.77%). The combination of 3000 m^3/fad., with Iquet for Marathon variety gave the highest root diameter value (26.8 cm) while the same combination with Farida variety recorded the highest sucrose percentage value (20.06%). Thus, the combination of 2500 m^3/fad., with Iquet for Marathon variety attained the highest root length (35.3 cm).

Key words: Irrigation rate, soil improvers, sugar beet varieties

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is considered to be the second most important sugar crop, after sugar cane, due to its production annually of 45% of the global sugar supply. Sugar beet is an economic crop in newly reclaimed areas and it produces more sugar under these conditions as compared with sugar cane. Division of Foreign Agriculture Service, United States Department of Agriculture (FAS-USDA 2016), reported that in 2015/16 season (Fig.1), Egypt produced 2.12

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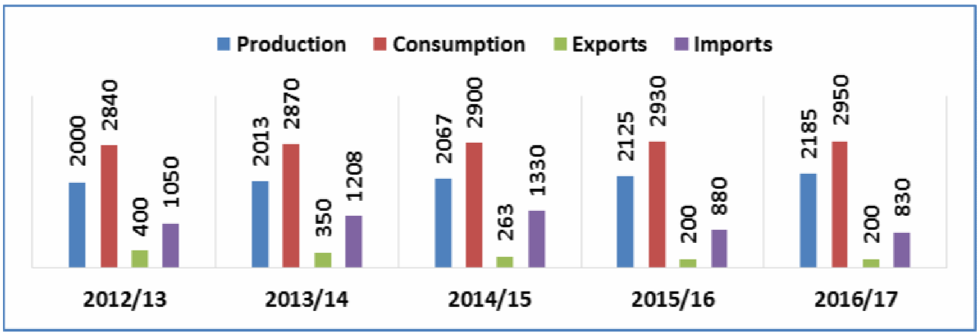

Fig. 1. Egypt's total production and consumption (1000 Metric tons)

Source: Foreign Agriculture Service, United States Department of Agriculture (FAS-USDA 2016)

million tons of sugar from 396,000 fad., of beet and 311,000 fad., of cane. Egypt consumes around 3 million tons (2.9, exactly) of sugar a year, using imports to fill the gap between production and consumption of sugar which reaches now nearly (765.000 tons). The increase in area harvested is due to the government's policy to encourage farmers to grow beets over cane to conserve water and also for its high sugar extraction that reaches 15-22 percent compared to only 14-16 percent for cane.

Sugar beet is grown in the Nile Delta region while sugar cane is grown in southern Egypt. Sugar beet is a new winter sugar crop and it has been a very successful crop in North Sinai, because it is tolerant to the shortage of irrigation water and the high salinity of the soil and water. Moreover, it is used for untraditional feed for large animals, sheep, and goats in North Sinai. Furthermore, there are some secondary industrial products from the residual leaf and root material. These residual and secondary products can supplement the income of farmers who produce sugar beet.

The performance of sugar beet varieties with respect to yield and the components of yield was studied by many authors. El-Hinnawy *et al.* (2003) found that sugar beet varieties differed significantly in sucrose content and purity percentage. El-Hennawy and El-Hawary (1995) and Bhullar *et al*. (2009) reported that sugar beet varieties differed in root and sugar yields (ton/fad.) as well as in sucrose percentage. Al-Sayed (1997) found large variances among sugar beet varieties with respect to top, root, sugar yields (ton/fad.), and sucrose percentage. El-Hawary and Mokadem (1999) found that there was a magnitude variation among sugar beet varieties regarding all the studied characters in both seasons. Oscar poly variety gave the highest values of fresh root weight, relative root yield and yields of top, root and sugar than other two sugar beet varieties. Abou-Salama and El-Sayed (2000) showed that root and sugar yields varied between cultivars: the mean root yield was 16.50 ton/fad., for cv. Ras poly and 26.10 ton/fad., for cv. Gazella. Sugar yield was highest (3.09 ton/fad.) in cv. Oscar poly. Soomro *et al.* (2006); Siodmiak (2007) and Ijoyah *et al.* (2008) evaluated the yield performance of sugar beet varieties and they found that varieties were significantly differed. Safina and Fatah (2011) reported that sugar beet varieties differed significantly in purity percentage, sucrose percentage, extractable sugar percentage, root and sugar yields traits in both seasons except for sugar yield and purity (%) in 1st season only. Ahmad *et al.* (2012) evaluated four sugar beet hybrid varieties under Pakistan soil conditions and they found that SD-PAK09/07 variety attained the highest sugar yield (9.35 ton/ha) with highest sugar content (12.60%) and root yield (74.2 ton/ha) followed by California and Magnolia varieties that gave sugar yield (7.08 and 6.99 ton/ha), respectively. The Mirabella variety produced a minimum sugar yield (4.44 ton/ha) and the lowest root yield among the tested varieties (40.33 ton/ha). Ahmad *et al.* (2012) also showed that there were no significant differences in root yield and size between the experimental varieties. El-Hawary *et al.* (2013) found that sugar beet varieties significantly differed in TSS (%), sucrose (%), and root and sugar yields/faddan in both seasons. The sugar beet variety Farida produced the highest values of TSS (%), sucrose (%), and root yield/faddan and sugar yield/faddan compared to other varieties in both seasons. Pacuta *et al*. (2013) found that Fred variety achieved the best production parameters from among four sugar beet varieties (Jambus, Tilman, Antek and Fred) and the highest sugar content was found in Tilman variety. LiangMin *et al*. (2014) evaluated three sugar beet varieties under Chinese soil conditions and they reported that the root yield of KWS7125 variety was 74.88-101.96 ton/ha, with 14.58-16.53% sugar content, while KWS0143 variety gave 85.86-89.21 ton/ha root yield and 13.41-15.74% sugar content and the KWS2049 variety gave 77.77-106.81 ton/ha root yield and 13.90-14.80% sugar content. Al-Sayed and Attaya (2015) reported that sugar beet varieties were significantly differed in root length in the 1st season, root diameter in the 2ndseason, root and sugar yields in both seasons. The highest values of root length and root diameter were resulted from Farida sugar beet variety. While, the highest values of juice purity percentage and sucrose percentage were resulted from Toro sugar beet variety. Also, Halawa variety attained the highest root and sugar yields.

Regarding the effect of irrigation rates on yield and its components**,** El-Hennawy and El-Hawary (1995) found that increasing depletion level of soil moisture significantly decreased yields of top, root and sugar (ton/fad). On the other hand, sucrose (%) significantly increased with increasing depletion level of soil moisture. Abd El-Wahab *et al.* (1996) reported that root and sugar yields (ton/fad.) were significantly increased as the level of irrigation increased, but sucrose (%) decreased with increasing levels of irrigation. Ramazan *et al.* (2011) found that increasing water deficits resulted in a relatively lower root and white sugar yields. El-Hawary *et al.* (2013) found that decreasing the amount of irrigation water from 3000 m^3 to 2500 and 2000 m^3 caused reductions in root and sugar yields per faddan. But, on the other hand, it increased the sucrose percentage in both seasons. Al-Sayed *et al.* (2014) noted that application irrigation rate of 2500 m^3/fad., recorded significantly the higher root length and purity percentage traits, meanwhile irrigation rate of 3000 m^3/fad., significantly raised root diameter and root yield traits.

Soil improvers/fertilizers importance for sugar beet production were reported by Blomquist and Berglund (2002), who showed that slaked lime (calcium hydroxide) improved the experimental soil and increased sugar yields. Negm *et al.* (2005) studied the response of sugar beet to sawdust compost (4 and 8 ton/fad.) and farmyard manure (12 tons/fad.) with combination of N sources, they reported that manuring increased the root yield of sugar beet significantly over the control, without differences between the three experimental manure treatments. Wallace and Carter (2007) studied the effect of compost on sugar beet yield. They found that the addition of organic matter, and nutrients from the application of compost, improved soil fertility and led to a 7% average increase in sugar beet yield. Zarishnyak and Sypko (2010) found that the application of press mud increased root yield to 40.2– 45.8 tons/ha compared to 26.2 tons/ha for the unfertilized control. Sugar yields were also increased to 6.9 – 8.0 tons/ha compared to 4.6 tons/ha for the control. Ambihai and Gnanavelrajah (2013) found that the addition of charred biomass had the potential to increase the root yield by improving soil properties and reducing losses due to leaching. Al-Sayed and Osman (2015) studied three soil treatments (control, Aquita and potassium humate) on yield and its components of two sugar beet varieties (Farida and Marathon), they found that both of soil treatment compounds attained a positive and significant increase on the studied traits compared with control.

The objective of this investigation was to study the effect of different irrigation rates and soil conditioners on yield and quality of three sugar beet varieties under new land conditions of North Sinai Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were conducted in the Experimental Farm, Environmental Agricultural Sciences Faculty (FEAS), Suez Canal University, North Sinai Governorate, Egypt (31°08'04.3" N, 33°49'37.2"E) during two winter successive seasons, 2012/2013 and 2013/2014, to study the effect of two rates of drip irrigation (2500 and 3000 m^3/fad.) and three soil improvers {Iquet, (9% Zn, 3.5% CaO, 0.6 S) powder which was added to the soil before sowing at the rate of 10 kg/fad., and Agrispon (liquid at the rate of 1 cm/10 m^2) and Humic acid 10% K_2O (powder at the rate of 2 gram/litre) which were added after thinning} on yield and its components of three sugar beet varieties: (Marathon, monogerm variety, as well as Farida, and Samba, multigerm varieties). The experiments were carried out in split-split plot design with three replications. The irrigation rates were randomly distributed in main plots, varieties in the sub-plots and soil conditioners were allocated at random in sub-sub plots. The plot area was 15 m^2 (6 rows × 0.5 m width × 5 m length).

Seeds of sugar beet varieties were provided by the Sugar Crops Research Institute (SCRI) Agricultural Research Center (ARC) Giza, Egypt. Sowing date was on the first week of October in both seasons, Sugar beet seeds were sown into hills 20 cm apart. When the plants reached at four leaf stage, they were thinned to one plant/hill. Phosphorus, in form of calcium super phosphate (15.5% P_2O_5), was added at a rate of 30 kg P_2O_5/fad., at sowing. Potassium sulfate (48% K_2O) was applied at a rate of 50 kg K_2O/fad., with the first nitrogen application. Nitrogen fertilizer was applied as ammonium sulfate (20% N) at a rate of 120 kg/fad., in three equal doses: after thinning, one month later, and three weeks later. Other cultural practices were done as recommended. Soil samples were selected randomly from different sites of the experimental field, from a depth of 0-30 cm (from the soil surface) before sowing. Chemical analysis of the irrigation water are presented in Table 1 also, chemical and physical properties of the experimental soil are presented in Table 2.

Data Recorded

At maturity (190 days from sowing) four guarded rows for each treatment were harvested, topped and cleaned. A sample of ten roots was taken at random from each plot to determine the following parameters

1- Root diameter (cm)

2- Root Length (cm)

3- Sucrose percentage was determined by using Sacchrometer according to the methods of AOAC (1990).

4- Juice purity percentage was calculated according to the method describing by Carruthers and Old Field (1961).

Juice purity (%) = {Sucrose (%)× 100/TSS}

5- Root yield (ton/fad.) was determined by harvest the four guarded rows, topped and weighted.

6- Sugar yield (ton/fad.) was calculated according the following equation:

Theoretical sugar yield (ton/faddan = Root yield (ton/fad.) × Sucrose (%)

Statistical Analysis

Data collected were subjected to the statistical analysis according to the methods described by Steel *et al.* (1997). Statistical difference among the means was analyzed by Duncan's multiple range test (DMRT) Duncan (1995) using the SAS (SAS Institute, 2000) and the results were expressed as the mean ± SE. Data were also subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The following discussion will include the effect of main factors on the studied characteristics, and because root yield is a final product for the growers and sugar is the final product for sugar factory, the interaction study will mean by the interaction between the studied factors on root and sugar yields only.

Root Length

Results given in Tables 3 and 4 show that root length of sugar beet varieties significantly affected by the examined irrigation rates in both growing seasons. Irrigation rate had a statistically significant effect for each level of variety × soil improver on the mean root length, $p < 0.005$ in 1st season and $p < 0.001$ in 2nd season. Irrigation rate of 2500 m^3/fad., over passed that of 3000 m^3/fad., which recorded the longest root (31.3 cm in 1st season and 32.6 cm in 2nd one). This finding is in harmony with that found by Al-Sayed *et al.* (2014) who noted that root length significantly increased with lower rate of irrigation water 2500 m^3. This finding may due to that less amount of water push the root to grow more than that of high rate of water supply.

Table 1. Chemical analysis of the irrigation water

pH	EC		Soluble ions (mq/l)							
	d.S/m	ppm	Cations				Anions			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCo_3-	Co_3--	So_4--
6.6	5.49	35.14	17.22	19.17	19.29	0.31	37.51	5.21	—	13.27

Table 2. Chemical and physical properties of the experimental soil during the two seasons

Season	2012/2013	2013/2014
Particle size distribution (%)		
Coarse sand (%)	68.30	68.28
Fine sand (%)	20.54	20.66
Silt (%)	4.43	4.39
Clay (%)	6.72	6.67
Texture class	Sand	Sand
Organic matter (%)	0.19	0.21
Chemical analysis in extraction soil		
a) Cations (mq/l)		
Ca^{++}	2.23	3.01
Mg^{++}	2.25	2.22
Na^{+}	3.99	3.82
K^{+}	0.28	0.48
b) Anions (mq/l)		
HCo^{-}	2.38	2.35
Cl^{-}	2.35	2.52
So_4^{--}	4.02	4.67
$CaCo_3$ (%)	4.77	4.78
EC (dS/m) (1:5)	0.89	0.84
pH (1:2.5)	8.25	8.20

In both seasons, the mean root length was different between the studied varieties at each level of irrigation × soil improver ($p < 0.05$). Marathon variety gave the highest values of root length (30.6 and 32.1 cm in 1st and 2nd seasons, respectively) followed by Farida variety that recorded (29.0 and 30.5 cm in 1st and 2nd seasons, respectively). While Samba variety recorded the lowest values of root length in 1st and 2nd seasons, respectively (27.3 and 28.0 cm). Where humic was applied at irrigation level of 3000 m^3/fad., the mean root lengths were statistically equivalent for the examined varieties of sugar beet ($F_{2, 34} = 1.03$, $p = 0.3687$). The differences between sugar beet varieties in root length had been reported by Ahmad *et al*. (2012) and Al-Sayed and Attaya (2015) who mentioned that sugar beet varieties were significantly differed in root length.

Therefore, all of the two-way interactions and all of the experimental factors were statistically significant as well. For each level of irrigation × variety the soil improver had a significant effect in 1st season ($p < 0.01$). The highest root length was recorded by Iquet soil improver (30.8 and 31.4 cm in 1st and 2nd seasons, respectively), followed by humic which gave (29.2 and 30.2 cm). On the other hand, Agrispone attained the lowest values of root length during the two seasons. However, in 2nd season, the mean root lengths for the Marathon variety were statistically equivalent for each experimental soil improver, at irrigation level 1 (2500 m^3/fad.) ($F_{2,34} = 1.14$, $p = 0.3315$). In 2nd season, the mean root lengths were statistically equivalent for the Samba variety across soil improvers at irrigation level of 3000 m^3/fad. ($F_{2,34} = 3.19$, $p = 0.0537$).

The three-way interaction of irrigation × variety × soil improver was statistically significant in 1st season ($F_{4, 34}$=3.97, p=0,0095) (Table 3), and also in 2nd season ($F_{4,34} = 5.08$, $p = 0.0025$) (Table 4). Using 2500 m^3/ fad., of irrigation rate in combination with Iquet as soil improver for Marathon sugar beet variety were recorded the highest root length values in 1st and 2nd seasons (35.2 ± 0.4 and 35.4 ± 0.5 cm, respectively). This finding is in agreement with that found by Al-Sayed and Osman (2015) who noted that highest root length was recorded with the combination between Marathon variety with 2500 m^3/fad., and Aquita component.

Root Diameter

Results in Tables 3 and 4 show that root diameter of sugar beet varieties significantly affected by the examined irrigation rates in both growing seasons also, in the 1st season irrigation level had a significant effect on root diameter at each level of variety × soil improver, except when Farida variety was grown with Iquet ($F_{1, 34} = 0.79$, $p = 0.3806$). In the 2nd season, irrigation level had a significant effect on the root diameter at each level of variety × soil improver, except when Samba variety was grown with Humic ($F_{1,34} = 0.79$, $p = 0.3806$). Moreover, results in Table 6 show that irrigation rate of 3000 m^3/fad over passed that of 2500 m^3/fad which recorded the highest root diameter (24.6 cm in 1st season and 25.7 cm in 2nd season). This finding is in agreement with that found by Al-Sayed *et al.* (2014) who noted that root diameter was larger under the higher irrigation rate of 3000 m^3.

Regarding the effect of sugar beet varieties on root diameter, results in Table 6 clear that Marathon variety gave the highest values of root diameter (23.8 and 25.2 cm in 1st and 2nd seasons, respectively) followed by Farida variety that recorded (23.7 and 25.0 cm in 1st and 2nd seasons, respectively). While Samba variety recorded the lowest values of root diameter in 1st and 2nd seasons, respectively (22.2 and 22.9 cm). In both seasons, sugar beet varieties had a significant effect on root diameter when humic was applied at irrigation level of 2500 m^3/fad. (1st season $F_{2, 34} = 5.80$, $p = 0.0068$; 2nd season $F_{2, 34} = 5.74$, $p = 0.0071$) and when Iquet was applied at irrigation rate of 2500 m^3/fad. (1st season $F_{2, 34} = 10.57$, $p = 0.0003$; 2nd season $F_{2, 34} = 22.02$, $p < 0.0001$). In both seasons, sugar beet varieties had a significant effect on root diameter at irrigation level of 3000 m^3/fad., when humic was applied (1st season $F_{2,34} = 9.67$, $p = 0.0005$; 2nd season $F_{2,34} = 14.29$, $p < 0.0001$). In 2nd season, sugar beet varieties had a significant effect on root diameter when Agrispon was applied at irrigation level of 3000 m^3/fad., ($F_{2,34} = 7.05$, $p = 0.0028$) and when Iquet was applied at irrigation level of 3000 m^3/fad., ($F_{2,34} = 8.79$, $p = 0.0008$). These findings are in agreement with those reported by Al-Sayed and Attaya (2015) who mentioned that sugar beet varieties were significantly differed in root diameter.

Table 3. Least squares-means estimates ± standard errors for first season, sugar beet variables with scheffé-adjusted grouping†

Irrigation rate (m^3/fad.)	Variety	Soil improver	Root length (cm)	Root diameter (cm)	Sucrose (%)
		Agrispon	28.4 ± 0.4^{def}	20.6 ± 0.5^{ef}	18.47 ± 0.15^{abc}
	Farida	Iquet	33.3 ± 0.4^{ab}	24.7 ± 0.5^{abcd}	19.40 ± 0.15^{a}
		Humic	31.6 ± 0.4^{bcde}	22.3 ± 0.5^{abcdef}	19.23 ± 0.15^{a}
		Agrispon	26.2 ± 0.4^{fg}	20.9 ± 0.5^{def}	17.67 ± 0.15^{c}
2500	Samba	Iquet	32.2 ± 0.4^{abcd}	21.4 ± 0.5^{cdef}	18.60 ± 0.15^{abc}
		Humic	29.4 ± 0.4^{cdef}	20.3 ± 0.5^{f}	18.47 ± 0.15^{abc}
		Agrispon	32.9 ± 0.4^{abc}	21.9 ± 0.5^{bcdef}	18.50 ± 0.15^{abc}
	Marathon	Iquet	35.2 ± 0.4^{a}	22.8 ± 0.5^{abcdef}	19.27 ± 0.15^{a}
		Humic	33.5 ± 0.4^{ab}	22.5 ± 0.5^{abcdef}	19.20 ± 0.15^{ab}
		Agrispon	25.6 ± 0.6^{fg}	24.3 ± 0.5^{abcdef}	18.77 ± 0.15^{abc}
	Farida	Iquet	28.4 ± 0.6^{def}	25.3 ± 0.5^{abc}	19.53 ± 0.15^{a}
		Humic	27.2 ± 0.6^{fg}	25.6 ± 0.5^{ab}	19.37 ± 0.15^{a}
		Agrispon	23.7 ± 0.6^{g}	23.2 ± 0.5^{abcdef}	18.03 ± 0.15^{bc}
3000	Samba	Iquet	26.5 ± 0.6^{fg}	25.3 ± 0.5^{abc}	19.20 ± 0.15^{ab}
		Humic	26.3 ± 0.6^{fg}	22.6 ± 0.5^{abcdef}	18.83 ± 0.15^{abc}
		Agrispon	25.4 ± 0.6^{fg}	24.6 ± 0.5^{abcde}	18.43 ± 0.15^{abc}
	Marathon	Iquet	29.8 ± 0.6^{bcdef}	26.3 ± 0.5^{a}	19.40 ± 0.15^{a}
		Humic	27.4 ± 0.6^{efg}	24.7 ± 0.5^{abcd}	19.57 ± 0.15^{a}

† Regarding root length, the following additional pair was significantly different: (1 2 2,1 1 1).

Table 4. Least squares-means estimates ± standard errors for second season, sugar beet variables with scheffé-adjusted grouping†

Irrigation rate (m^3/fad.)	Variety	Soil improver	Root length (cm)	Root diameter (cm)	Sucrose (%)
		Agrispon	30.7 ± 0.5^{bcdef}	22.3 ± 0.4^{cde}	18.80 ± 0.13^{cde}
	Farida	Iquet	34.2 ± 0.5^{ab}	24.9 ± 0.4^{abcd}	20.37 ± 0.15^{ab}
		Humic	33.4 ± 0.5^{abc}	23.6 ± 0.4^{bcde}	19.53 ± 0.16^{abcde}
		Agrispon	28.2 ± 0.5^{defg}	21.0 ± 0.4^{e}	18.30 ± 0.16^{e}
2500	Samba	Iquet	31.8 ± 0.5^{abcd}	21.7 ± 0.4^{de}	18.53 ± 0.12^{de}
		Humic	30.7 ± 0.5^{bcdef}	22.3 ± 0.4^{cde}	18.77 ± 0.14^{cde}
		Agrispon	35.2 ± 0.5^{a}	22.2 ± 0.4^{cde}	19.00 ± 0.15^{cde}
	Marathon	Iquet	35.4 ± 0.5^{a}	25.6 ± 0.4^{abc}	18.60 ± 0.15^{de}
		Humic	34.3 ± 0.5^{ab}	24.4 ± 0.4^{abcde}	19.27 ± 0.12^{bcde}
		Agrispon	27.2 ± 0.5^{efg}	26.4 ± 0.4^{ab}	19.00 ± 0.13^{cde}
	Farida	Iquet	29.2 ± 0.5^{cdefg}	26.7 ± 0.4^{ab}	20.60 ± 0.15^{a}
		Humic	28.7 ± 0.5^{defg}	26.3 ± 0.4^{ab}	20.50 ± 0.16^{ab}
		Agrispon	25.4 ± 0.5^{g}	24.4 ± 0.4^{abcde}	18.43 ± 0.16^{de}
3000	Samba	Iquet	26.9 ± 0.5^{fg}	24.9 ± 0.4^{abcd}	19.73 ± 0.12^{abc}
		Humic	25.2 ± 0.5^{g}	23.3 ± 0.4^{bcde}	19.20 ± 0.14^{cde}
		Agrispon	27.6 ± 0.5^{defg}	26.4 ± 0.4^{ab}	19.23 ± 0.15^{bcde}
	Marathon	Iquet	31.4 ± 0.5^{abcde}	27.4 ± 0.4^{a}	19.63 ± 0.15^{abcd}
		Humic	29.3 ± 0.5^{cdef}	25.9 ± 0.4^{ab}	19.60 ± 0.12^{abcd}

† Regarding sucrose, the following additional pairs are significantly different: (2 1 3,1 3 3), (1 1 2,1 3 3), (2 3 2,1 2 2), (2 3 3,1 2 2), (2 3 3,2 2 1).

Table 5. Effect of interaction between irrigation rates and soil improvers on root length of some sugar beet varieties

Irrigation rate m³/fad.	Variety	2012/2013 Soil improver Agrispon	Iquet	Humic	Mean	2013/2014 Soil improver Agrispon	Iquet	Humic	Mean
2500	Farida	28.4	33.3	31.6	31.1	30.7	34.2	33.4	32.7
	Samba	26.2	32.2	29.4	29.2	28.2	31.8	30.7	30.2
	Marathon	32.9	35.2	33.5	33.8	35.2	35.4	34.3	34.9
Mean		29.1	33.5	31.5	31.3	31.3	33.8	32.8	32.6
3000	Farida	25.6	28.4	27.2	27.0	27.2	29.2	28.7	28.3
	Samba	23.7	26.5	26.3	25.5	25.4	26.9	25.2	25.8
	Marathon	25.4	29.8	27.4	27.5	27.6	31.4	29.3	29.4
Mean		24.9	28.2	26.9	26.6	26.7	29.1	27.7	27.8
Soil improvers mean		27.0	30.8	29.2		29.0	31.4	30.2	
Varieties mean	Farida				29.0				30.5
	Samba				27.3				28.0
	Marathon				30.6				32.1

Table 6. Effect of interaction between irrigation rates and soil improvers on root diameter of some sugar beet varieties

Irrigation rate m³/fad.	Variety	2012/2013 Soil improver Agrispon	Iquet	Humic	Mean	2013/2014 Soil improver Agrispon	Iquet	Humic	Mean
2500	Farida	20.6	24.7	22.3	22.5	22.3	24.9	23.6	23.6
	Samba	20.9	21.4	20.3	20.8	21.0	21.7	22.3	21.6
	Marathon	21.9	22.8	22.5	22.4	22.2	25.6	24.4	24.0
Mean		21.1	22.9	21.7	21.9	21.8	24.0	23.4	23.0
3000	Farida	24.3	25.3	25.6	25.0	26.4	26.7	26.3	26.4
	Samba	23.2	25.3	22.6	23.7	24.4	24.9	23.3	24.2
	Marathon	24.6	26.3	24.7	25.2	26.4	27.4	25.9	26.5
Mean		24.0	25.6	24.3	24.6	25.7	26.3	25.1	25.7
Soil improvers mean		22.5	24.2	23.0		23.7	25.1	24.2	
Varieties mean	Farida				23.7				25.0
	Samba				22.2				22.9
	Marathon				23.8				25.2

Concerning the effect of soil improvers on root diameter, results in Table 6 show that the highest root diameter was recorded due to Iquet soil improver application (24.2 and 25.1 cm in 1st and 2nd seasons, respectively), followed by Humic which gave (23.0 and 24.2 cm). On the other hand, the lowest values of root diameter during the two seasons were attained due to Agrispone application. This finding is in line with those reported by Al-Sayed and Attaya (2015) who mentioned that Aquita compound recorded the highest values of root diameter. Moreover, In both seasons, the soil improver had a statistically significant effect on Farida root diameter at irrigation level of 2500 m^3/fad., (1st season $F2,34 = 16.64$, $p < 0.0001$; 2nd season $F2,34 = 8.93$, $p = 0.0008$) and on Samba root diameter at irrigation level of 3000 m^3/fad., (1st season $F2,34 = 7.78$, $p = 0.0016$; 2nd season $F2,34 = 3.67$, $p = 0.0362$). In 1st season, the soil improver had a significant effect on Marathon root diameter at irrigation 3000 m^3/fad., ($F2, 34 = 3.57$, $p = 0.0391$). In 2nd season, the soil conditioner had a significant effect on Marathon variety root diameter at irrigation 2500 m^3/fad., ($F2, 34 = 15.38$, $p < 0.0001$).

The three-way interaction of irrigation × variety × soil improver was significant in 1st season ($F4,34 = 3.87$, $p = 0.0107$) (Table 3) but not in 2nd season ($F4,34 = 1.87$, $p = 0.1380$) (Table 4). Moreover, using 3000 m^3/fad., of irrigation rate in combination with Iquet as soil improver for Marathon sugar beet variety recorded the highest root diameter values in 1st and 2nd seasons (26.3 ± 0.5 and 27.4 ± 0.4 cm, respectively).

Sucrose Percentage

Sucrose percentage is one of the important parameters that briefly give an idea about the expected sugar extractives. Results given in Tables 3 and 4 show that sucrose percentage of sugar beet varieties significantly affected by the examined irrigation rates in both growing seasons. In both seasons, irrigation levels had a significant effect on sucrose when Samba variety was grown with Iquet (1st season $F1, 34 = 8.63$, $p = 0.0059$; 2nd season $F1, 34 = 49.85$, $p < 0.0001$). In 2nd season, however, the irrigation levels also had a significant effect when Farida variety was grown with Humic ($F1, 34 = 18.28$, $p = 0.0001$), when Samba variety was grown with Humic ($F1,34 = 4.97$, $p = 0.0325$), and when Marathon variety was grown with Iquet ($F1,34 = 24.03$, $p < 0.0001$). Moreover, results in Table 7 show that irrigation rate of 3000 m^3/fad., over passed that of 2500 m^3/fad., which recorded the highest percentage of sucrose (19.01% in 1st season and 19.54% in 2nd season). This result is in line with that reported by El-Hennawy and El-Hawary (1995) who found that increasing depletion level of soil moisture significantly increased sucrose percentage.

Regarding the effect of sugar beet varieties on sucrose percentage, results in Table 7 clear that Farida variety gave the highest values of this trait in 1st and 2nd seasons (19.12 and 19.79%), respectively followed by Marathon variety that recorded (19.06 and 19.21 % in 1st and 2nd seasons, respectively). While Samba variety recorded the lowest values of sucrose percentage in 1st and 2nd seasons, respectively (18.46 and 18.82 %). Therefore, varieties had significant effect for most of the levels of irrigation × soil improver in 1st season ($p < 0.005$), except when Iquet was applied at irrigation rate of 3000 m^3/fad., ($F2, 34 = 1.35$, $p = 0.2727$). In 2nd season, varieties had a significant effect for every level of irrigation × soil improver ($p \leq 0.01$).

Once more, the effect of soil improvers on sucrose percentage, results in Table 7 show that the highest percentage was recorded by Iquet soil improver (19.23 and 19.57 % in 1st and 2nd seasons, respectively), followed by Humic which gave (19.10 and 19.47 %). On the other hand, Agrispone produced the lowest values of sucrose percentage during the two seasons. However in 1st season, for every level of irrigation × variety, the soil improver had a significant effect ($p < 0.005$), but in 2nd season, the soil improver did not have a significant effect on Samba variety sucrose levels at irrigation rate of 2500 m^3/fad. ($F2, 34 = 2.47$, $p = 0.0993$), and the soil improver did not have a significant effect on Marathon variety sucrose levels at irrigation rate of 3000 m^3/fad., ($F2,34 = 2.24$, $p = 0.1224$).

The three-way interaction of irrigation × variety × soil improver did not have a significant effect on sucrose percentage in 1st season (F4,34

Table 7. Effect of interactions between irrigation rates and soil improvers on sucrose percentage of some sugar beet varieties

Irrigation rate m³/fad.	Variety	2012/2013				2013/2014			
		Soil improver			Mean	Soil improver			Mean
		Agrispon	Iquet	Humic		Agrispon	Iquet	Humic	
2500	Farida	18.47	19.40	19.23	19.03	18.80	20.37	19.53	19.56
	Samba	17.67	18.60	18.47	18.24	18.30	18.53	18.77	18.53
	Marathon	18.50	19.27	19.20	18.99	19.00	18.60	19.27	18.95
Mean		18.21	19.09	18.96	18.75	18.70	19.16	19.19	19.01
3000	Farida	18.77	19.53	19.37	19.22	19.00	20.60	20.50	20.03
	Samba	18.03	19.20	18.83	18.68	18.43	19.73	19.20	19.12
	Marathon	18.43	19.40	19.57	19.13	19.23	19.63	19.60	19.48
Mean		18.41	19.37	19.25	19.01	18.88	19.98	19.76	19.54
Soil improvers mean		18.31	19.23	19.10		18.79	19.57	19.47	
Varieties mean	Farida				19.12				19.79
	Samba				18.46				18.82
	Marathon				19.06				19.21

= 0.80, p = 0.5349) (Table 3). Nevertheless, in 2nd season, the three-way interaction had a significant effect on sucrose percentage ($F_{4,34}$ = 4.42, p = 0.0055) (Table 4). The Scheffé adjustment that was used in the Tables is a single-step adjustment for multiple comparisons, so it was not necessary for the F ratio for the three-way interaction to be statistically significant in order for the differences between the levels of the three-way interaction to be considered to be statistically significant. Furthermore, using 3000 m^3/fad., of irrigation rate in combination with Iquet as soil improver for Farida sugar beet variety recorded the highest sucrose percentage value (20.06% as a mean of both seasons) followed by the same variety with the same irrigation rate but with Humic as soil improver that gave (19.93% as a mean of both seasons).

Juice Purity Percentage

Results given in Tables 8 and 9 point out that purity percentage of sugar beet varieties significantly affected by the examined irrigation rates in 1st season, the irrigation levels had a significant effect on purity only when Farida variety was grown with Agrispon ($F_{1,34}$ = 24.24, p < 0.0001) and when Marathon variety was grown with Iquet ($F_{1,34}$ = 13.35, p = 0.0009). Irrigation rate of 2500 m^3/fad., over passed that of 3000 m^3/fad., only in the 1st season (Table 10) which recorded the highest purity percentage (94.24%), this finding is in agreement with that found by Al-Sayed *et al.* (2014) who noted that irrigation rate of 2500 m^3 recorded significantly higher purity (%) than 3000 m^3. Nevertheless, in the 2nd season, the rate of 3000 m^3/fad., over passed that of 2500 m^3/ fad., that attained 95.19%. As for the combination of both seasons, the irrigation rate of 3000 m^3/fad., over passed the other rate on purity percentage trait.

As for the effect of sugar beet varieties on purity percentage, results in Table 10 clear that Farida variety gave the highest value of this trait in each of 1st and 2nd seasons (95.07 and 95.80%), respectively followed by Marathon variety that recorded (94.25 and 95.42% in 1st and 2nd seasons, respectively). While Samba variety recorded the lowest values of this trait in both seasons. Furthermore, in 1st season, the variety

Table 8. Least squares-means estimates ± standard errors for 1st season, sugar beet variables with scheffé-adjusted grouping†

Irrigation rate (m³/fad.)	Variety	Soil improver	Purity (%)	Root yield (ton/fad.)	Sugar yield (ton/fad.)
2500	Farida	Agrispon	94.00±0.34[abcd]	23.24±0.24[ef]	4.29±0.06[hi]
		Iquet	96.11±0.28[ab]	27.60±0.24[bc]	5.35±0.06[abc]
		Humic	94.33±0.33[abcd]	26.29±0.24[cd]	5.06±0.06[cde]
	Samba	Agrispon	93.33±0.36[cd]	21.95±0.24[fg]	3.88±0.06[ij]
		Iquet	94.22±0.34[abcd]	25.45±0.24[d]	4.73±0.06[efg]
		Humic	92.66±0.37[d]	23.51±0.24[ef]	4.34±0.06[gh]
	Marathon	Agrispon	93.66±0.35[bcd]	24.46±0.24[de]	4.52±0.06[fgh]
		Iquet	96.22±0.27[ab]	28.09±0.24[abc]	5.41±0.06[abc]
		Humic	93.66±0.35[bcd]	25.47±0.24[d]	4.89±0.06[def]
3000	Farida	Agrispon	94.11±0.34[abcd]	23.12±0.22[efg]	4.34±0.06[gh]
		Iquet	95.44±0.30[abc]	28.70±0.22[ab]	5.61±0.06[ab]
		Humic	96.44±0.27[a]	27.27±0.22[bc]	5.28±0.06[bcd]
	Samba	Agrispon	92.44±0.38[d]	21.42±0.22[g]	3.86±0.06[j]
		Iquet	93.77±0.35[bcd]	28.22±0.22[ab]	5.42±0.06[abc]
		Humic	93.33±0.36[cd]	25.52±0.22[d]	4.81±0.06[ef]
	Marathon	Agrispon	93.33±0.36[cd]	24.64±0.22[de]	4.54±0.06[fgh]
		Iquet	94.66±0.32[abcd]	29.42±0.22[a]	5.71±0.06[a]
		Humic	94.00±0.34[abcd]	29.43±0.22[a]	5.76±0.06[a]

Table 9. Least squares-means estimates ± standard errors for 2nd season, sugar beet variables with scheffé-adjusted grouping†

Irrigation rate (m³/fad.)	Variety	Soil improver	Purity (%)	Root yield (ton/fad.)	Sugar yield (ton/fad.)
2500	Farida	Agrispon	94.44±0.42[ab]	24.54±0.19[i]	4.61±0.05[h]
		Iquet	96.66±0.29[a]	28.42±0.19[def]	5.79±0.05[abc]
		Humic	95.33±0.39[ab]	27.59±0.19[fg]	5.39±0.05[cde]
	Samba	Agrispon	93.22±0.46[b]	22.16±0.19[j]	4.05±0.05[i]
		Iquet	95.00±0.36[ab]	27.11±0.19[fg]	5.02±0.05[efg]
		Humic	94.66±0.41[ab]	26.16±0.19[gh]	4.91±0.05[fgh]
	Marathon	Agrispon	94.55±0.41[ab]	25.25±0.19[hi]	4.80±0.05[gh]
		Iquet	95.44±0.34[ab]	29.44±0.19[bcd]	5.48±0.05[bcd]
		Humic	96.11±0.35[ab]	27.60±0.19[fg]	5.32±0.05[def]
3000	Farida	Agrispon	94.33±0.42[ab]	25.60±0.19[hi]	4.86±0.07[fgh]
		Iquet	97.00±0.28[a]	30.55±0.19[ab]	6.29±0.07[a]
		Humic	97.11±0.31[a]	29.51±0.19[bcd]	6.05±0.07[a]
	Samba	Agrispon	94.22±0.42[ab]	22.21±0.19[j]	4.09±0.07[i]
		Iquet	94.55±0.37[ab]	29.07±0.19[cde]	5.74±0.07[abcd]
		Humic	93.11±0.46[b]	27.76±0.19[ef]	5.33±0.07[cdef]
	Marathon	Agrispon	94.44±0.42[ab]	25.59±0.19[hi]	4.92±0.07[efgh]
		Iquet	95.89±0.32[ab]	30.34±0.19[abc]	5.96±0.07[ab]
		Humic	96.11±0.35[ab]	31.74±0.19[a]	6.22±0.07[a]

† Regarding sugar yield, the following additional pairs are significantly different: (2 1 2,1 1 2), (1 1 2,1 1 3), (1 3 3,1 2 3).

had a significant effect on purity for most levels of irrigation × soil improver ($p < 0.01$), except when Agrispon was applied at irrigation level of 2500 m^3/fad., (1st season F2, 34 = 0.91, p = 0.4122; 2nd season F2, 34 = 3.00, p = 0.0630). In 2nd season, the variety also did not have a significant effect when Agrispon was applied at 3000 m^3/fad., irrigation level (F2, 34 = 0.07, p = 0.9293).

Concerning the effect of soil improvers on purity percentage, results in Table 10 show that the highest percentage was recorded by Iquet soil improver (95.06 and 95.75% in 1st and 2nd seasons, respectively), followed by Humic which gave (94.07 and 95.40%). On the other hand, Agrispone produced the lowest values of this trait during the two seasons. However, in 1st season, the soil improver had a significant effect on purity at every level of the irrigation × variety interaction ($p < 0.05$). In 2nd season, the soil improver had a significant effect on purity at most levels of the irrigation × variety interaction ($p < 0.05$), except when Samba variety was grown at 3000 m^3/fad., irrigation level (F2, 34 = 3.26, p = 0.0507).

The three-way interaction of irrigation × variety × soil improver did not have a significant effect on purity in 1st season (F4, 34 = 2.53, p = 0.0588) (Table 8). Nevertheless, in 2nd season, the three-way interaction had a significant effect on purity (F4, 34 = 4.51, p = 0.0050) (Table 9). Moreover, using 3000 m^3/fad., of irrigation rate in combination with Humic as soil improver for Farida sugar beet variety recorded the highest purity percentage values in 1st and 2nd seasons (96.44 and 97.11%, respectively).

Root Yield (ton/fad.)

Results given in Tables 8 and 9 show that root yield of sugar beet varieties significantly affected by the examined irrigation rates in both growing seasons. In the 1st season, irrigation treatments had a significant effect on root yield at most levels of variety × soil improver ($p < 0.005$) except when Farida variety was grown with Agrispon (F1,34 = 0.15, p = 0.7031), Samba variety was grown with Agrispon (F1,34 = 2.85, p = 0.1007), and when Marathon variety was grown with Agrispon (F1, 34 = 0.33, p = 0.5680). Similarly, in the 2nd season, irrigation treatments had a significant effect on root yield at most levels of variety × soil improver ($p < 0.005$), except when Samba variety was grown with Agrispon (F1, 34 = 0.04, p = 0.8467) and when Marathon variety was grown with Agrispon (F1, 34 = 1.76, p = 0.1940). However, results in Table (11) show that irrigation rate of 3000 m^3/fad., over passed that of 2500 m^3/fad., which recorded the highest root yields (26.41 and 28.03 ton/fad., in 1st and 2nd seasons, respectively). The results are in harmony with that found by Abd El-Wahab *et al.* (1996) and El-Hawary *et al.* (2013) who reported that root yield (ton/fad.) was significantly increased as the level of irrigation increased.

Regarding the effect of sugar beet varieties on root yield, results in Table 11 clear that Marathon variety gave the highest values of root yield (26.91 and 28.32 ton/fad., in 1st and 2nd seasons, respectively) followed by Farida variety that recorded (26.03 and 27.70 ton/fad., in 1st and 2nd seasons, respectively). While Samba variety recorded the lowest values of root yield in both seasons. Varieties had a significant effect on root yield at every level of irrigation × soil improver in 1st season ($p < 0.005$) and 2nd season ($p < 0.0001$). The results are in line with that reported by Al-Sayed and Osman (2015). The differences between varieties in this character could be due to the differences between the used varieties in their genetically aspects.

Concerning the effect of soil improvers on root yield, results in Table 11 show that the highest root yield was recorded by Iquet soil improver (27.91 and 29.15 ton/fad., in 1st and 2nd seasons, respectively), followed by Humic which gave (26.24 and 28.39 ton/fad). On the other hand, Agrispone gave the lowest values of root yield during the two seasons. In both seasons, soil improver had a highly significant effect on root yield at every level of irrigation × variety ($p < 0.0001$). The influence of soil conditioners on root yield had been reported by Zarishnyak and Sypko (2010) and Ambihai and Gnanavelrajah (2013) who mentioned that the addition of press mud and charred biomass had the potential to increase the root yield by improving soil properties.

The three-way interaction of irrigation × variety × soil improver had a significant effect on sugar beet root yield in 1st season (F4, 34 =

Table 10. Effect of interactions between irrigation rates and soil improvers on purity percentage of some sugar beet varieties

Irrigation rate m^3/fad.	Variety	2012/2013				2013/2014			
		Soil improver			Mean	Soil improver			Mean
		Agrispon	Iquet	Humic		Agrispon	Iquet	Humic	
	Farida	94.00	96.11	94.33	94.81	94.44	96.66	95.33	95.47
2500	Samba	93.33	94.22	92.66	93.40	93.22	95.00	94.66	94.29
	Marathon	93.66	96.22	93.66	94.51	94.55	95.44	96.11	95.36
Mean		93.66	95.51	93.55	94.24	94.07	95.70	95.36	95.04
	Farida	94.11	95.44	96.44	95.33	94.33	97.00	97.11	96.14
3000	Samba	92.44	93.77	93.33	93.18	94.22	94.55	93.11	93.96
	Marathon	93.33	94.66	94.00	93.99	94.44	95.89	96.11	95.48
Mean		93.29	94.62	94.59	94.16	94.33	95.81	95.44	95.19
Soil improvers mean		93.47	95.06	94.07		94.20	95.75	95.40	
	Farida				95.07				95.80
Varieties mean	Samba				93.29				94.12
	Marathon				94.25				95.42

Table 11. Effect of interactions between irrigation rates and soil improvers on root yield of some sugar beet varieties

Irrigation rate m^3/fad.	Variety	2012/2013				2013/2014			
		Soil improver			Mean	Soil improver			Mean
		Agrispon	Iquet	Humic		Agrispon	Iquet	Humic	
	Farida	23.24	27.60	26.29	25.71	24.54	28.42	27.59	26.85
2500	Samba	21.95	25.45	23.51	23.63	22.16	27.11	26.16	25.14
	Marathon	24.46	28.09	25.47	26.00	25.25	29.44	27.60	27.43
Mean		23.21	27.04	25.09	25.11	23.98	28.32	27.11	26.47
	Farida	23.12	28.70	27.27	26.36	25.60	30.55	29.51	28.55
3000	Samba	21.42	28.22	25.52	25.05	22.21	29.07	27.76	26.34
	Marathon	24.64	29.42	29.43	27.83	25.59	30.34	31.74	29.22
Mean		23.06	28.78	27.40	26.41	24.46	29.98	29.67	28.03
Soil improvers mean		23.13	27.91	26.24		24.22	29.15	28.39	
	Farida				26.03				27.70
Varieties mean	Samba				24.34				25.74
	Marathon				26.91				28.32

11.15, $p < 0.0001$) (Table 8) and in 2nd season ($F_{4,34} = 17.70$, $p<0.0001$) (Table 9). Moreover, using 3000 m^3/fad., of irrigation rate in combination with Humic as soil improver for Marathon sugar beet variety were recorded the highest root yield values in 1st and 2nd seasons (29.43±0.2 and 31.74±0.1 ton/fad, respectively).

Sugar Yield (ton/fad.)

Results given in Tables 8 and 9 show that in the 1st season, the irrigation treatments had a significant effect for most levels of variety × soil improver ($p < 0.005$), except when Farida variety was grown with Agrispon ($F_{1,34} = 0.42$, $p = 0.5194$) – and, in both seasons, irrigation treatments did not have a significant effect when Samba variety was grown with Agrispon (1st season $F_{1,34} = 0.05$, $p = 0.8271$; 2nd season $F_{1,34} = 0.21$, $p = 0.6506$) and when Marathon variety was grown with Agrispon (1st season $F_{1,34} = 0.06$, $p = 0.8060$; 2nd season $F_{1,34} = 2.11$, $p = 0.1556$). Therefore, results in Table 12 show that irrigation rate of 3000 m^3/fad., over passed that of 2500 m^3/fad., which recorded the highest sugar yields (5.03 and 5.49 ton/fad., in 1st and 2nd seasons, respectively). This finding is in harmony with that found by Abd El-Wahab *et al.* (1996) and El-Hawary *et al.* (2013) who mentioned that increasing quantity or the level of irrigation water increased significantly sugar yield (ton/fad.).

Varieties had a significant effect on sugar yield at every level of irrigation × soil improver in both seasons ($p < 0.005$). Results in Table 12 clear that Marathon variety gave the highest values of sugar yield (5.13 ton/fad, in 1st season) however, in the 2nd season, Farida variety recorded the highest sugar yield (5.49 ton/fad). While Samba variety recorded the lowest values of sugar yield in both seasons. These findings are in agreement with those reported by El-Hennawy and El-Hawary (1995), Al-Sayed (1997), El-Hawary and Mokadem (1999), Abou-Salama and El-Sayed (2000), Nassar (2001), El-Hinnawy *et al.* (2003), El-Hawary *et al.* (2013) and Al-Sayed and Attaya (2015) who mentioned that sugar beet varieties were significantly differed in sugar yield.

Table 12. Effect of interactions between irrigation rates and soil improvers on sugar yield of some sugar beet varieties

Irrigation rate m^3/fad.	Variety	2012/2013				2013/2014			
		Soil improver			Mean	Soil improver			Mean
		Agrispon	Iquet	Humic		Agrispon	Iquet	Humic	
2500	Farida	4.29	5.35	5.06	4.90	4.61	5.79	5.39	5.26
	Samba	3.88	4.73	4.34	4.31	4.05	5.02	4.91	4.66
	Marathon	4.52	5.41	4.89	4.94	4.80	5.48	5.32	5.20
Mean		4.23	5.16	4.76	4.71	4.48	5.43	5.20	5.04
3000	Farida	4.34	5.61	5.28	5.07	4.86	6.29	6.05	5.73
	Samba	3.86	5.42	4.81	4.69	4.09	5.74	5.33	5.05
	Marathon	4.54	5.71	5.76	5.33	4.92	5.96	6.22	5.70
Mean		4.24	5.58	5.28	5.03	4.62	5.99	5.86	5.49
Soil improvers mean		4.23	5.37	5.02		4.55	5.71	5.53	
Varieties mean	Farida				4.98				5.49
	Samba				4.50				4.85
	Marathon				5.13				5.45

Concerning the effect of soil improvers on sugar yield, results in Table 12 show that the highest sugar yield was recorded by Iquet soil improver (5.37 and 5.71 ton/fad, in 1st and 2nd seasons, respectively), followed by Humic which gave (5.02 and 5.53 ton/fad). On the other hand, Agrispone produced the lowest values of sugar yield during the two seasons. In both seasons, soil improver had a highly significant effect on sugar yield at every level of irrigation × variety ($p < 0.0001$). The influence of soil conditioners on sugar yield had been reported by Blomquist and Berglund (2002), Wallace and Carter (2007) and Zarishnyak and Sypko (2010) who mentioned that the addition of soil conditioner improved the experimental soil and increased sugar yield.

The three-way interaction of irrigation × variety × soil improver had a significant effect on sugar yield in the 1st season ($F_{4,34} = 11.26$, $p < 0.0001$) (Table 8) and in 2nd season ($F_{4,34} = 5.09$, $p = 0.0025$) (Table 9). Moreover, using 3000 m^3/fad., of irrigation rate in combination with Humic as soil improver for Marathon sugar beet variety recorded the highest sugar yield values in 1st and 2nd seasons (5.76 and 6.22 ton/fad., respectively).

Conclusion

It can be concluded that the studied varieties especially Marathon and/or Farida irrigated with 3000 m^3/fad., with using Iquet as soil improver could be recommended for maximizing sugar beet productivity and juice quality under the environmental conditions of El-Arish, North Sinai, Egypt.

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تأثير معدلات الري بالتنقيط ومحسنات التربة على أداء بعض أصناف بنجر السكر في شمال سيناء

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الهدف من هذا البحث هو دراسة تأثير معدلين للري بالتنقيط (٢٥٠٠، ٣٠٠٠ م^{٣}/فدان) وثلاثة محسنات تربة (إكويت، اجريسبون، هيوميك) على محصول وجودة ثلاثة أصناف من بنجر السكر (فاريدا، ماراثون، سامبا) تحت ظروف الأراضي الجديدة بمحافظة شمال سيناء، وأظهرت النتائج بأن لمعدلات الري تأثيراً معنوياً على صفات طول وقطر الجذر ونسبة السكروز ومحصول الجذور والسكر في كلا الموسمين بينما كان لها تأثيراً معنوياً في الموسم الأول فقط على صفة نسبة نقاوة العصير حيث تفوق معدل الري ٣٠٠٠ م^{٣}/فدان عن معدل الري ٢٥٠٠ م^{٣}/فدان والذي أدى للحصول على أعلى القيم لصفات قطر الجذر ونسبة السكروز ونسبة نقاوة العصير وكذلك محصول الجذور والسكر في حين سجل معدل الري ٢٥٠٠ م^{٣}/فدان أعلى القيم لصفة طول الجذر، بالإضافة إلى انه كان للأصناف أيضا تأثيراً معنوياً على صفات طول وقطر الجذر ونسبة السكروز ومحصولي الجذور والسكر في كلا الموسمين بينما كان لها تأثيراً معنوياً فقط على صفة نقاوة العصير في الموسم الأول فقط حيث أعطى الصنف ماراثون اعلى القيم لصفات طول وقطر الجذر وكذلك محصولي الجذور والسكر في حين أعطى الصنف فاريدا أعلى القيم لصفات نسبة السكروز ونسبة نقاوة العصير، وبالنسبة لتأثير محسنات التربة فلقد أظهرت تأثيراً معنوياً على صفات قطر الجذر ونسبة النقاوة ومحصولي الجذور والسكر في كلا الموسمين الزراعيين بينما كان لها تأثيراً معنوياً فقط في الموسم الأول على صفات طول الجذر ونسبة السكروز، وكان إكويت أفضل محسنات التربة حيث سجل أعلى القيم لجميع الصفات المدروسة في كلا الموسمين، وبالنسبة لتأثير تداخل عوامل الدراسة الثلاثة، فلقد حققت تأثيراً معنوياً على صفة قطر الجذر في الموسم الأول وعلى صفات نسبة السكروز ونسبة نقاوة العصير في الموسم الثاني وعلى صفات طول الجذر ومحصولي الجذور والسكر في كلا الموسمين حيث أدى استخدام معدل الري ٣٠٠٠ م^{٣}/فدان مع محسن التربة هيوميك على الصنف ماراثون للحصول على أعلى محصول للجذور (٣٠,٥٨ طن/فدان) ومحصول السكر (٥,٩٩ طن/فدان) خلال الموسمين. كذلك أدى استخدام نفس معدل الري مع نفس محسن التربة على الصنف فاريدا للحصول على أعلى نسبة نقاوة للعصير (٩٦,٧٧%) ، ومن ناحية أخرى أدى استخدام ٣٠٠٠ م^{٣}/فدان مع محسن التربة إكويت على الصنف ماراثون للحصول على اعلى قيمة لصفة قطر الجذر (٢٦,٨ سم) بينما سجل نفس التداخل ولكن على الصنف فاريدا أعلى نسبة سكروز (٢٠,٠٦%)، أيضاً أدى استخدام معدل الري ٢٥٠٠م^{٣}/ فدان مع محسن التربة إكويت على الصنف ماراثون للحصول على اعلى قيمة لصفة طول الجذر (٣٥,٣ سم).

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